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TESTING OF ULTRASONIC SENSOR FOR MEASUREMENT OF WASTE VEGETAION MASS

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Abstract: *The object of the study is an ultrasonic sensor type UT2F/E7-OEUL which measures the presence of a body in the range of 350 to 6000 mm. The sensor was mounted in a suitable place in the combine harvester. Experiments were conducted on three types of waste vegetation mass (WVM): wheat, beans and alfalfa in field and laboratory conditions. A database of sensor measurements was obtained. A single-factor dispersion analysis task was formulated. The results obtained using relevant specialized software showed that the sensor is operational regardless of the type of WVM.*

Keywords: *ANOVA, vegetation mass, experiment, dispersion analyze, ultrasonic sensor*

INTRODUCTION

The waste vegetation mass (WVM) from plant-growing is a stream of plant stems that are obtained after harvesting, i. e. after they are cut off by the cutter bar of the combine harvester. Before the harvest, the stems have some order that is determined by the sowing, but after cutting, this order is disturbed and they form a flow in a chaotic state. This flow is characterized by a different density of flow thickness in the closed space of a combine over the straw walker. This space is determined by a fixed transverse dimension **b**, which is embedded in the combine harvester construction (Figure 1). The other WVM flow parameter is the speed at which it moves to the input of the machine. This speed is determined by the so-called "load applied" to the combine **Q** in kg/s, i.e. quantity of harvested mass per unit of time, (Georgiev, I., Stanev St, 1989). If the speed of the combine harvester is greater, **Q** also increases, resulting in higher losses of unthreshed grain. The speed of movement of the harvested mass entering a combine harvester, for example, for key straw walker, is also determined by the rotation speed of the crankshaft, which gives them a movement. For a given machine, it is obtained as the linear velocity expressed by the product of the angular velocity along the length of the crank shaft drive of the crank length **r** (Figure 1). The key of the straw walker is a link with a common plane motion from a four-bar linkage planar mechanism. The both cranks are the same size so that each key performs a flat, circular translational movement. As a result, the linear velocity along its entire length is the same, which ensures a uniform distribution and movement of the straw mixed with grain in the longitudinal direction of the combine harvester.

The object of this study is to measure the volume of WVM above the straw walker with a UT2F/E7-OEUL ultrasonic sensor in different crops to determine their effect on sensor measurements.

EXPOSITION

Stage of the study

The WVM stream in a combine harvester is characterized by the transverse size of the straw walker **b**, their velocity $\mathbf{V_{strw.}}$, with which they move the straw and the height **h(t)** which is variable. Namely, it is subject to measurement by primary transducers. In previous publications, such a solution has been studied using a potentiometric sensor (pos.18 of Figure 2), (Panayotov, L., & R. Mihaylov, 2015), (Panayotov, L., 2016), (R. Mihajlow, R., L. Panajotov, St. Stoianov & D. Mihaylova, 2016).

Figure 1 shows the dimensions of the parallelepiped along which the WVM passes over a given period of time. The positions in the Figure are: 1 - bearing support on the combine harvester frame; 2 - crank; 3 - bearing support on one of the straw walker keys; 4 - the straw walker key.

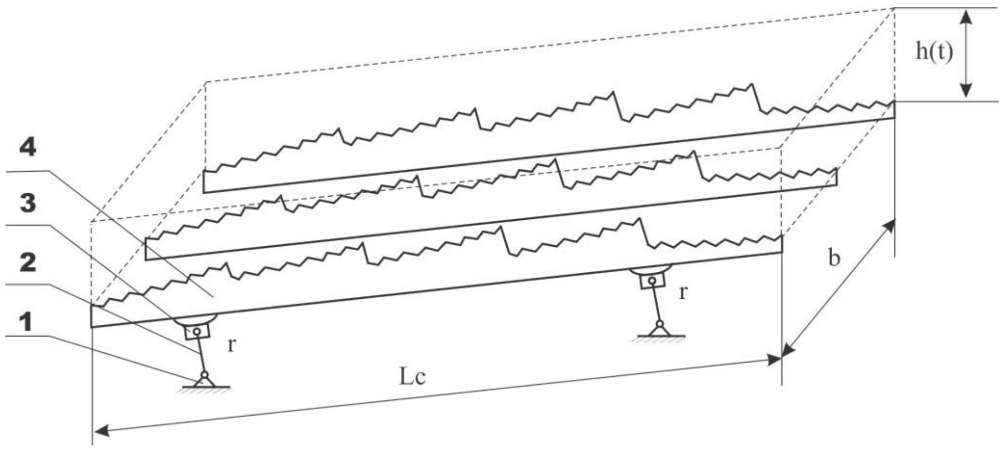

Fig.1. Dimensions of the WVM space in the combine harvester:
Lc - length, **b** - width, **h(t)** - height of straw layer, and **r** is the length of the crank.

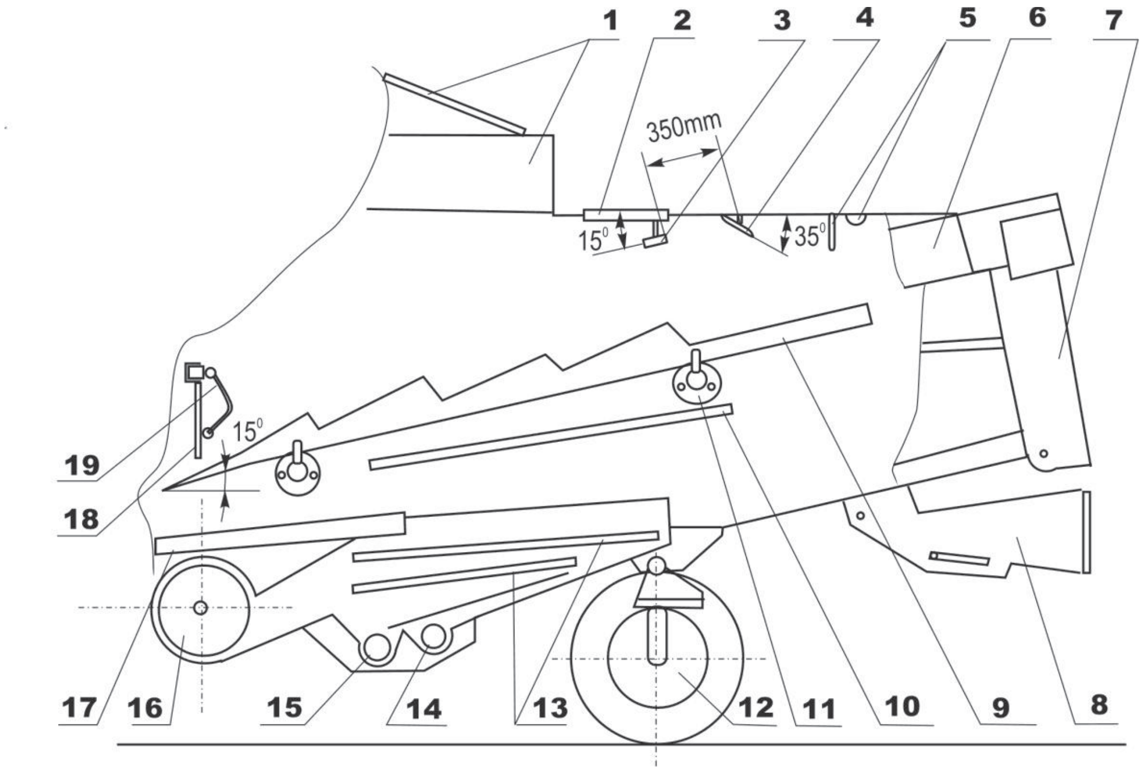

Fig.2. Mounting of the UT2F/E7-OEUL ultrasonic and potentiometric sensors on the grain combine harvester to measure the quantity of WVM

The positions in Figure 2 are: 1 - grain tank and cover; 2 - cover over the straw walker; 3 - ultrasonic sensor type: UT2F/E7-0EUL; 4 - reflector for the ultrasonic sensor; 5 – the straw walker overload sensor; 6 – uploading auger; 7 - casing at the straw outlet; 8 - straw chopper; 9 - the key of straw walker; 10 - grain pan; 11 - bearing of the drive crank; 12 - rear suspension and wheel of the combine harvester; 13 - bottom sieve; 14 – tailings conveyor 15 - grain auger; 16 - fan; 17 - grain pan; 18 - rubber curtain (tranquilizer); 19 - potentiometric sensor.

It is known that sensors that emit an ultrasonic high frequency beam are characterized by the so-called "dead zone" (Tomov, P., & A. Angelov, 2011), which for the particular model of that sensor is 350 mm long.

In order to gain a place in the zone where the WVM moves inside a combine harvester, the rays of the sensor are directed to the measuring site after they are reflected by a "mirror" (pos. 4, Figure 2) placed on their path at an angle of 45°.

Experimental results

Experiments were carried out with different species of WVM: wheat straw in field conditions, lucerne and bean stalks in laboratory conditions (Fig.3, 4). The measurement results formed the database.

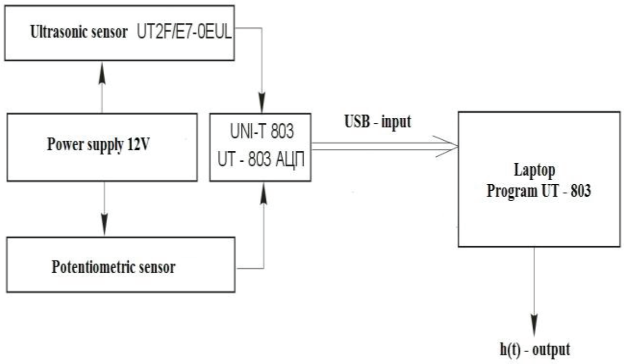

Fig.3. Block diagram of the devices for measuring the quantity of WVM

Fig.4. Experimental layout

Solving the task by one-factor dispersion analysis

The problem formulated above is solved by creating a mathematical model, (Mitkov, A., 2011), which includes one factor **A** with three levels (**m = 3)** of manifestation: **a1, a2** and **a3**, which are determined by the three types of WVM. Ten measurements (**n**) were performed for each crop. The data from the parallel experiments are presented in Table 1.

The task was to establish at a level of significance **α = 0,05** whether the **A**-factor influences the parameter **Y** - the measured thickness of the WVM layer.

Table 2. gives the results of the single-factor dispersion analysis, where **n = 10**. The degrees of freedom: of the sums **SS - k = n-1 = 9**; of the sums SS_A, characterizing the deviations from the conditional average arithmetic values - $k_A = m-1 = 3-1 = 2$ and the sums SS_E, characterizing the influence of non-steady and unrecorded factors on the parameter **Y** - $k_E = N-m = 30-3=27$, where

$$N = \sum_{i=1,j=1}^{3,30} n_{i,j} \tag{1}$$

The experimental value of the Fisher criterion was obtained, which in true zero hypothesis and fulfilled prerequisites of the dispersion assumptions has **F** distribution with degrees of freedom $k_1 = k_A = 2$ and $k_2 = k_E = 27$. The calculated value of **F** is less (**F = 1,527,** see Table 2.) than the one defined in Appendix 2, (Mitkov, A., 2011), which is: $F_{0,05;(2,27)} = 3,371$.

Table 1.

	a	y
1	a1	,582
2	a1	,513
3	a1	,480
4	a1	,349
5	a1	,375
6	a1	,297
7	a1	,216
8	a1	,553
9	a1	,667
10	a1	,451
11	a2	,130
12	a2	,367
13	a2	,546
14	a2	,299
15	a2	,382
16	a2	,474
17	a2	,435
18	a2	,296
19	a2	,270
20	a2	,431
21	a3	,494
22	a3	,420
23	a3	,367
24	a3	,468
25	a3	,416
26	a3	,362
27	a3	,414
28	a3	,539
29	a3	,370
30	a3	,361

Table 2.

	Summs of square	**Degree of freedom**	**Assessments of dispersions**	**Fisher criterion**
Factor A	SS_A=0,038	m-1=2	S_A^2=0,019	F_A=1,527
Random and unreported factors	SS_E=0,336	N-m=27	S_E^2=0,0124	
Summarize influence	SS=0,374	N-1=29	S^2=0,0128	

CONCLUSION

Factor **A** does not have a significant effect on the values of the WVM thickness of different crops. This means that the ultrasonic sensor can be successfully used to measure the thickness of the WVM layer from different field crops. For this purpose, it is necessary to set a maximum and minimum size for the thickness of the layer in advance as specified in the sensor passport.

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